IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	W. H. BERRYMAN, H. B. McDONALD	
Serial No.	:	10/814,178	
Filed	:	April 1, 2004	Group Art Unit 3746
Examiner	:	WEINSTEIN, LEONARD J	
Title	:	PUMP CONTROL SYSTEM	

DECLARATION UNDER 37CFR 1.131

I, Dr. W. H. (Wal) Berryman of 34 Richardson Road, Croydon, Victoria, 3136, Australia, declare that:

1. I am one of the inventors of the invention as claimed in US Application No. 10/814,178. The other inventor is H. B. (Hugh) McDonald.

2. I have been advised that in a First Office Action dated 10/03/2007 the claims of the application in question have been rejected as either prior published or as obvious based on, principally, a US Patent No. 6,631,638 in the name of James et al. I have been further advised that the James et al citation has an effective date under 35 USC§102(e) and/or 35 USC§ 102(e)/103 of January 30, 2001.

3. As is evidenced below, I and Hugh McDonald reduced the claimed invention for practice prior to the effective date of January 30, 2001 of the James et al reference US 6,631,638.

4. Attachment E to this Declaration lists the current claims of the application and indicates where claimed elements are disclosed in the accompanying documents which support the earlier reduction to practice. In broad terms, the claimed invention (summarizing claim 1) is a pump controller which

comprises pressure sensing means and flow sensing means (including a heater and a temperature responsive element) implemented on an insulating layer on surface of a metal substrate (i.e, a plate) for sensing the flow and pressure of a fluid, such as water, over the opposite surface of the metal plate. The pump controller additionally includes a switch (for switching the pump on and off) and a processor for operating the switch based on data inputs from the pressure and flow sensing means. The insulating layer on the metal plate furthermore includes conductive tracks for the data flow from the pressure and flow sensing means. The switch is preferably a triac (claim 7) which may be mounted on the metal plate (claim 8).

5. Also claimed is a housing for at least the metal plate substrate and it's componentry which is designed to prevent leakage of the fluid medium flowing over the opposite surface of the metal plate to the surface having the insulating layer and electronic componentry. This aspect of the invention is defined by claim 12 (and illustrated for example in Fig. 4 of the application).

6. In January 2000, Davey Products Pty Ltd issued a design specification for a pump controller and I (via my company, Hybrid Electronics Australia Pty Ltd, of which I am Managing Director) decided to submit a design to meet the specification. Attachment A to this Declaration is a copy of the contents page and sections 1 to 4.3 of the design specifications (I have attached only this portion of the extensive specification to illustrate its substantive requirements). The bottom left hand corner of each page carries the date "14/01/00" indicating an issue date of January 14, 2000.

7. The concept underlining the invention of using thick film technology, that is flow sensor components printed on a dielectric coating on a metal plate and incorporating a pressure sensor based on high sensitivity strain gauge resistors also printed on the dielectric coating, was developed by me and Hugh McDonald (and is a development from an earlier invention by me and Hugh McDonald -- see WO 91/19170 which is referenced in the application). In reducing the invention to practice, my company worked in collaboration

with other companies, namely Australian Arrow Pty Ltd and Artimech. A first prototype of the pump controller was reduced to practice by October 2000.

8. On Nov 8, 2000, I demonstrated the working prototype, in conjunction with a PowerPoint presentation, to Davey Products Pty Ltd. Attachment B is a copy of an email dated 8 Nov 2000 from Mark Lance, the General Manager - Engineering, of Davey Products Pty Ltd to a "Robert Puts", reserving a room for the presentation. Attachment C provides copies of some of the slides from the PowerPoint presentation. The first slide titled "Building Innovative Pump Solutions" is a photograph of the demonstration equipment set-up. The pump controller prototype is in the T section piping marked with an asterisk. The second slide titled "Project Overview" is self explanatory. The third slide titled "Technology Concept" describes the implementation of the electronics (flow and pressure sensors) on an insulating layer on a stainless steel plate. The fourth slide, also titled "Technology Concept" includes a photograph (the left hand picture) of the first prototype of the pump controller. The fifth slide titled "Packaging Concepts" is also self explanatory and indicates that the housing the subject of claim 12, was also part of the development. The sixth slide labeled "Screw-in Stainless Steel Design" shows figures of the design. The metal substrate (that is a stainless steel plate) carrying the dielectric layer with the electronic componentary and conductive tracks thereon is labeled "Hybrid" in the figures. The switch is also shown, labeled "Triac", as is the housing of claim 12, labeled "Cover". The seventh slide titled "Screw-in Stainless Steel Design" shows a performance graph for pressure measurement via the pressure sensor of the invention (which is implemented as a resistive strain gauge – as claimed by claim 5 of the application). The eighth slide, also titled "Screw-in Stainless Steel Design" shows a performance graph for the flow sensing means of the invention. The ninth slide, titled "Electronics", includes reference to a microprocessor, illustrating use of a processor as defined in claim 1 of the application.

9. The documentation referred to in paragraph 8 shows that the claimed invention was reduced to practice nearly three months prior to the effective date of the James et al reference.

10. Further evidence of the reduction to practice of the claimed invention is demonstrated by Attachment D, which is a Design Report dated November 2000 on the Development of the Pump Controller. In the body of the Report, in Section 1.2, the text under the heading "Cover-Hybrid" refers to the housing of claim 12 of the application and the text under the heading "Hybrid Substrate" refers to the metal substrate element of claim 1 of the application, and Part 2 of the Report "Design Report on Electronics Developments by Hybrid Electronics" relates to the electronics elements of claim 1 of the application. This Report shows that proof of concept embodiment (i.e. a reduction to practice) of the claimed pump controller and the claimed housing had been completed and tested by about mid November 2000, and further that the developmental work mentioned in the Report relates merely to optimizing performance and making refinements for production.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements are made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of this Application or any Patent issuing therefrom.

14 - March 2008
Date

W. H. Berryman

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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Serial No.	:	10/814,178	
Filed	:	April 1, 2004	Group Art Unit 3746
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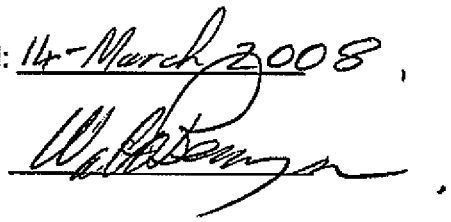
ATTACHMENT A

to the Declaration of W. H. Berryman

Dated: 14-March 2008



CONTENTS

1 SCOPE

This document defines requirements, specifications and possible features for the pump control unit being developed by Davey Pumps.

The document also includes specifications for prototype acceptance tests.

This document does not include pump requirements.

This document must be signed off before any product design and development work can be finalised.

2 APPLICABLE DOCUMENTS

2.1 Applicable Standards and Regulatory Requirements

The following standards and regulatory requirements are applicable to the product. See also section 4.9.

AS 3000:1991	SAA Wiring Rules
AS 1044.1 & AS 1044.2 :1995	Limits & methods of measurement of radio interference characteristics of household electrical appliances
SECLAB approval or equivalent	Prescribed item for Australian application
AS4020/BS6920/ANSI/NSF 61	Potable water
AS 2926-1987	Standard voltages Alternating (50Hz) and direct
AS2279-1979	Disturbances in mains supply networks
IEC38	IEC Standard Voltages
AS/NZS 3350.1-1988	Safety of household and similar electrical appliances.
AS/NZS 3350.2.51:1998	"Particular requirements - stationary circulation pumps for heating & service water installations".
U.S. Middle East and European equivalents (see assumptions sheet)	UL, CE, C4 (EMC)

3 DEFINITIONS AND ABBREVIATIONS

3.1 Definitions

'Pump control unit' refers to the pressure control unit to be designed. This may also be referred to as 'the product'.

3.2 Acronyms and Abbreviations

BOM	*Bill of Materials*
COG	*Cost of Goods*
CPM	*Cycles per minute*
EMC	*Electromagnetic Compatibility*
EMI	*Electromagnetic Interference*
IEC	*International Electrotechnical Commission*
ISO	*International Standards Organisation*
LPM	*Liters per minute flow rate*
MRD	*Market requirements document*
OEM	*Original equipment manufacturer*
PRD	*Product requirements document*
TBA	*To Be Advised – This information is not currently known or available*

3.3 Notes

"Shall" and "Must" denote mandatory requirements
"Should" denotes preference requirements.

Each Requirement has a letter assigned to it to represent one of the following:

[A]	Requirements for all products in the range
[B1, B2]	Requirements for specific product profiles
	B1 = Base line product "street fighter', domestic only.
	B2 = Top of the range, light commercial target
[C]	Optional extras or "add-ons" not included in specific product (If required)

4. PRODUCT LEVEL REQUIREMENTS

4.1 General Requirements

Requirement	Validation and Verification	Implementation / Notes	
4.1.1 Compliance with Standards		*[A]*	Date/Initial
The product must meet relevant ISO and IEC standards, as specified in section 2.1. and 4.9.	Verification by internal testing against standards. Final Validation by external testing by regulatory authority.	Many of these are specific to target markets and countries. These must therefore be specified.	
4.1.2 Intended Use		*[A]*	Date/Initial
The product is intended to be used to control domestic and light commercial (see notes) water pressure pumps. This may include use on non-Davey manufactured OEM pumps.	Data on the range of Davey pumps will be supplied.	Varying turbulence, especially at low flow, must be accommodated for OEM pumps.	
4.1.3 Product Unit Life		*[A]*	Date/Initial
The failure rate of the product is not to exceed - Zero - Two years 0.5% Two - Five years 2% Five - Ten years 20%	Life estimation is available from design calculations and verified statistically with an accelerated life test, as described in this document.	Lifecycle assumptions are covered in attached document 'Pump control unit assumptions'. Lifecycles – 1.65M cycles @ various temperatures, voltages and pressure cycles described in the designated document. 100% testing will be required of all production units for leak resistance and function, until capability can be assured.	

4.1.4 Durability		[A] Date/Initial
Davey will supply details of their durability test programs Field trials in Middle East and all intended markets – 6 months in operation	Environmental tests to be performed by the vendor Field trials by Davey	Assume 99% Capability and reliability. 150 operations per day for 10 years. Operational cycles will include ambient temperatures of +80 (25%) and – 20 C (25%) Must be proved at 110V and 240V, at extremes of pressure range of the accumulator fitted. All range / models to be tested.

4.2 Physical Requirements

Requirement	Validation and Verification	Implementation / Notes
4.2.1 Inlet/Outlet Connections		[A] Date/Initial
The standard inlet connection shall be a 1 1/2" male thread on both options. (To suit Davey barrel union or equivalent) The outlet connection shall be 1" male BSP thread on B1 and 1 1/4" on B2. The tool should be inserted at the outlet to allow manufacture of a NPT threaded outlet. Priming and/or attachment of a small external accumulator should be incorporated into the design, if possible. The product must incorporate a non-return valve and this valve must be capable of working in the presence of a non-return valve on the suction side of the pump.	Verify by design inspection	Thread options may be achieved using a tool insert, which must be designed (but not built) as part of the project. Inlet/outlet connections should be robust and resistant to damage by use of adjustable spanner or Stilson. Torques - 90Nm. A 1" 'Philmac' socket will fail in preference to the device body to reduce warranty.

4.2.3 Outlet Orientation		***[A]***	Date/Initial
The product must include an integral 90 degree elbow, allowing a horizontal outlet when attached to the top of a Davey pump. Should allow 360 degree direction adjustment by rotating the product before tightening the barrel union.		As practised on existing Hydrascan unit.	
4.2.4 Interchangeability		***[A]***	Date/Initial
The product must be dimensionally interchangeable with the existing Hydroscan. The outlet height will be within +/- 25 mm of the existing Hydrascan outlet height.			
4.2.5 Carrying & Handling		***[A]***	Date/Initial
The product must support without damage a pump weighing 25 kg, using the unit as a handle.	XD 192 pump out of box using mechanism as handle	A Davey, XD 192 pump will form the test weight. XD = 25 kg	
4.2.6 Robustness		***[A]***	Date/Initial
Must pass 1 drop test of 1 meter onto a smooth concrete surface. Any orientation.		See also 4.4.6. Note –Control unit needs to be resistant to change in pressure settings due to vibration or impact.	

4.3 Performance Requirements

Requirement	Validation and Verification	Implementation / Notes	
4.3.1 Static Pressure		***[A]***	Date/Initial
The pump system must maintain pressure at all times in a static system, so that there is always water available (under pressure) when a tap is turned on.		Needs an accumulator, able to supply a minimum of 30ml.	
4.3.3 Loss of Prime		***[A]***	Date/Initial
The product shall detect loss of prime and stop the pump within 30 sec if there is risk of damage to pump (ie no water present or zero flow). The controller must automatically restart the pump whenever there is water flow through the unit. Additionally, the unit must be capable of using elapsed time to trigger the restart.		Loss of prime criteria - loss of pressure and no flow for 30 sec. Loss of prime function will always be active. The provisional retry timing parameters will be 5 min, 1st try, then 30m, 1 hr, 2hrs, 4, 8, 16, 32hrs and stop. The elapsed time restart parameters must be capable of being reprogrammed at factory level. Note – unless an alternate discharge path is provided as part of the unit, provision must be made for a manual retry button. The unit cannot automatically reprime without an available discharge path.	
4.3.4 Responsiveness		***[A]***	Date/Initial
The controller must allow a minimum flow rate of 1.5 litre / Min. @ 35 degrees Celsius.		Tolerance on minimum flow rate +/- 0.5 liters per minute. This rate must be reprogrammable at a factory level. (See also 4.3.8, desirability of lower flow rate.)	
4.3.5 Pressure Range		***[A]***	Date/Initial
The product must be capable of operating at the specified pressures		Operating pressures (kPa) / Range / Back pressure: B1 — 140 - 700 / 1,500; B2 — 400 – 1,000 / 1,500	

4.3.6 Maximum Pressure Spike		[A]	Date/Initial
The control unit must be capable of withstanding a pressure spike induced by the specified test cycle for 20K cycles.		Test using 10 meters x 1" galvanised water pipe with no bends or suitably constrained, at a flow rate of 3 meters per second. A solenoid valve is to be used to instantaneously interrupt flow.	
4.3.7 Maximum Pressure Drop and Flow Rate		**[A]**	**Date/Initial**
The pressure drop across the product must be minimised. The target profile is shown in attached graph – 'Head loss in pump control unit'		This pressure drop shall include any turbulence suppression device, if required.	
4.3.8 Cycling		**[A]**	**Date/Initial**
The pump shall not cycle more frequently than 6 times per minute in conjunction with an intelligent variable run-on timer. Needs intelligence to recognise slow-filling toilets, etc.	Note – potential problem with dripping tap mode	One cycle is defined as the pump turning on and off. If pump has cycled 5 times in one minute, it will remain on for a 2 minute period on the 6th cycle. A desirable alternative would be to drop to a lower flow rate on 6th cycle (0.8 l/m). Also see 4.7.3, slow leak indicator.	

4.4 Operating Environment

Requirement	Validation and Verification	Implementation / Notes	
4.4.1 Weather Proofing		**[A]**	**Date/Initial**
The enclosure shall be resistant to an IP56 standard. This protects against both dust and a strong directed jet of water. The units performance must not be adversely affected by 10 years exposure to direct sunlight.		Inlet/outlet connections shall also be weatherproof (IP 56) Note – Press Control rating is IP65	

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ATTACHMENT B

to the Declaration of W. H. Berryman

Dated: 14 - March 2008

-----Original Message-----
From: Mark Lance [mailto:mlance@davey.com.au]
Sent: Wednesday, 8 November 2000 11:11
To: Robert Puts (E-mail) (E-mail)
Subject: Monsoon presentation

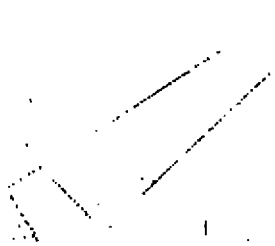
Hi Robert,

This afternoon at 4.00PM, the Australian Arrow consortium are going to present their detailed submission for the new pump controller. This will include a working model which will be demonstrated.

I would like to borrow the training center again, from 4 to 6 PM, if you do not have anything planned there. I understand that a condition of use is that it will have to be returned to a clean condition and any foreign installations must be removed.

Please let me know immediately if this is a problem and also if you wish to attend. You are more than welcome.

Mark



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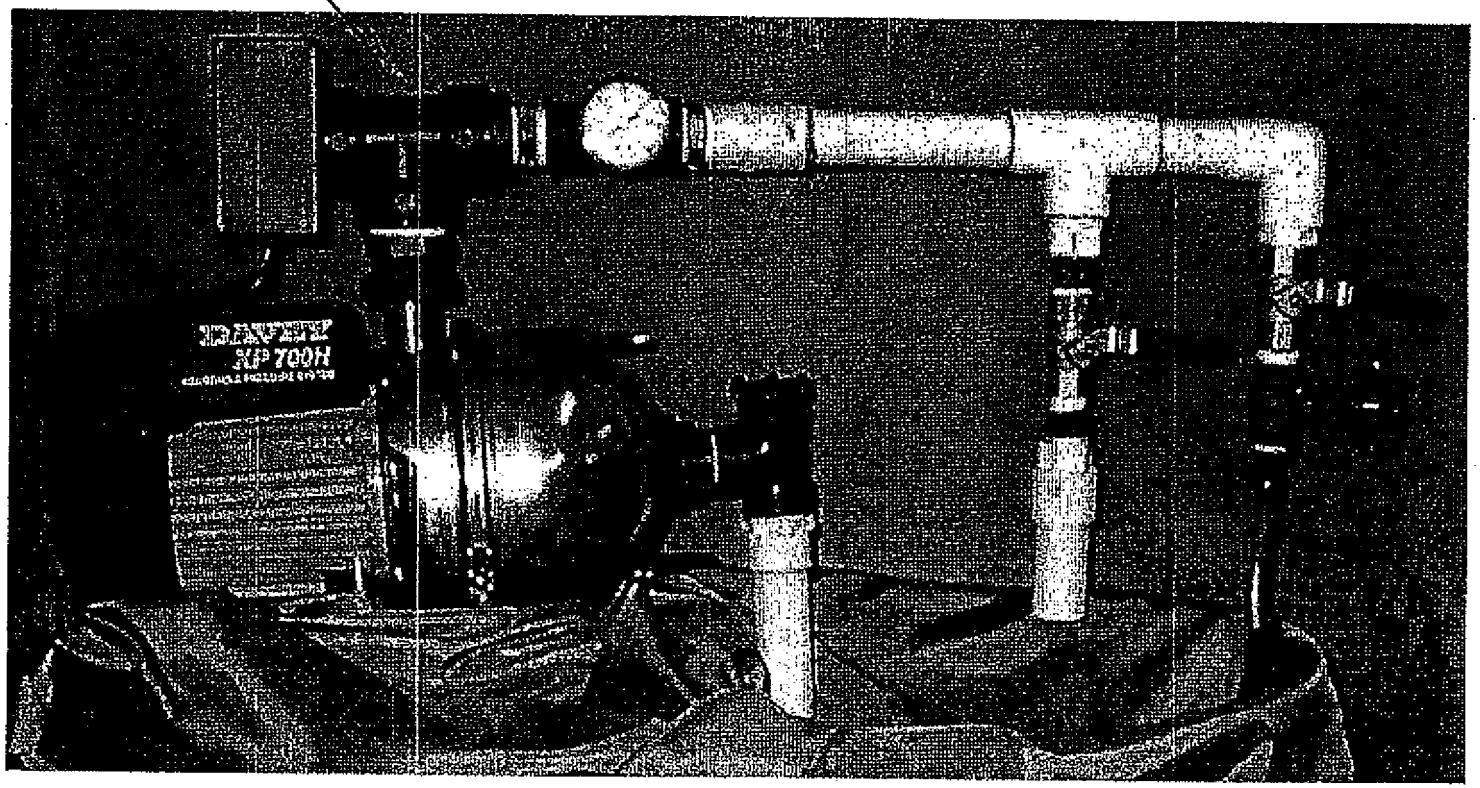
ATTACHMENT C

to the Declaration of W. H. Berryman

Dated: 14 - March 2008

Building Innovative Pump Solutions



Project Overview

To develop the world's best pump controller which has the following characteristics:

- Accurate flow and pressure sensing;
- Intelligent electronics to provide adaptive pump turn-on and cut-off;
- Full protection for the pump;
- High reliability;
- Internationally cost competitive.

Technology Concept

We are proposing two technology concepts using thick film on stainless steel:

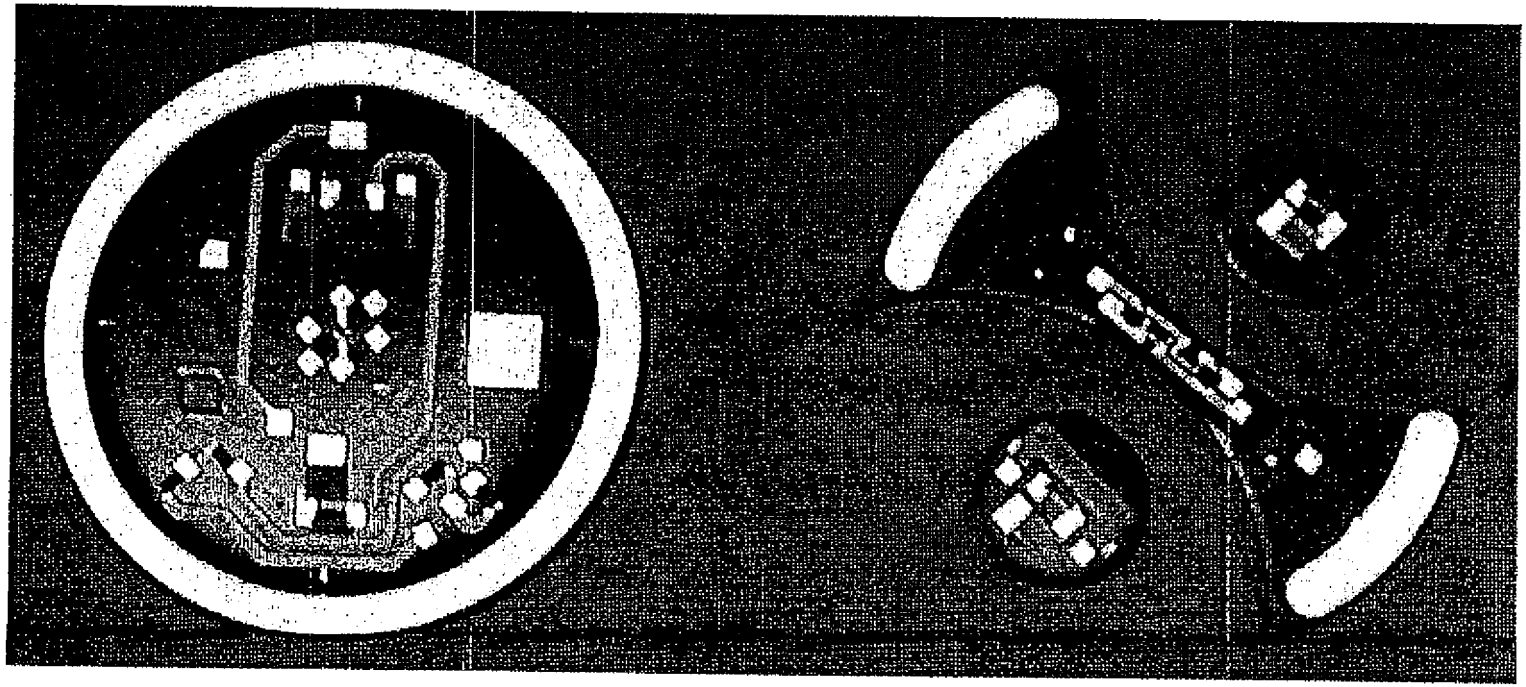
- A **flow sensor** based on the current hydrascan technology;
- A **pressure sensor** based on high sensitivity strain gauge resistors printed on a dielectric coating on the stainless steel;

As with all hybrids, the electronics can be mounted on the flat, printed steel to produce a complete circuit.

The result is excellent flow and pressure sensor characteristics which are suitable for the next generation pump control.

Technology Concept

Examples of prototypes printed and fired on stainless steel substrates for pressure and flow sensor transducers.



Packaging Concepts

We are also proposing two packaging concepts:

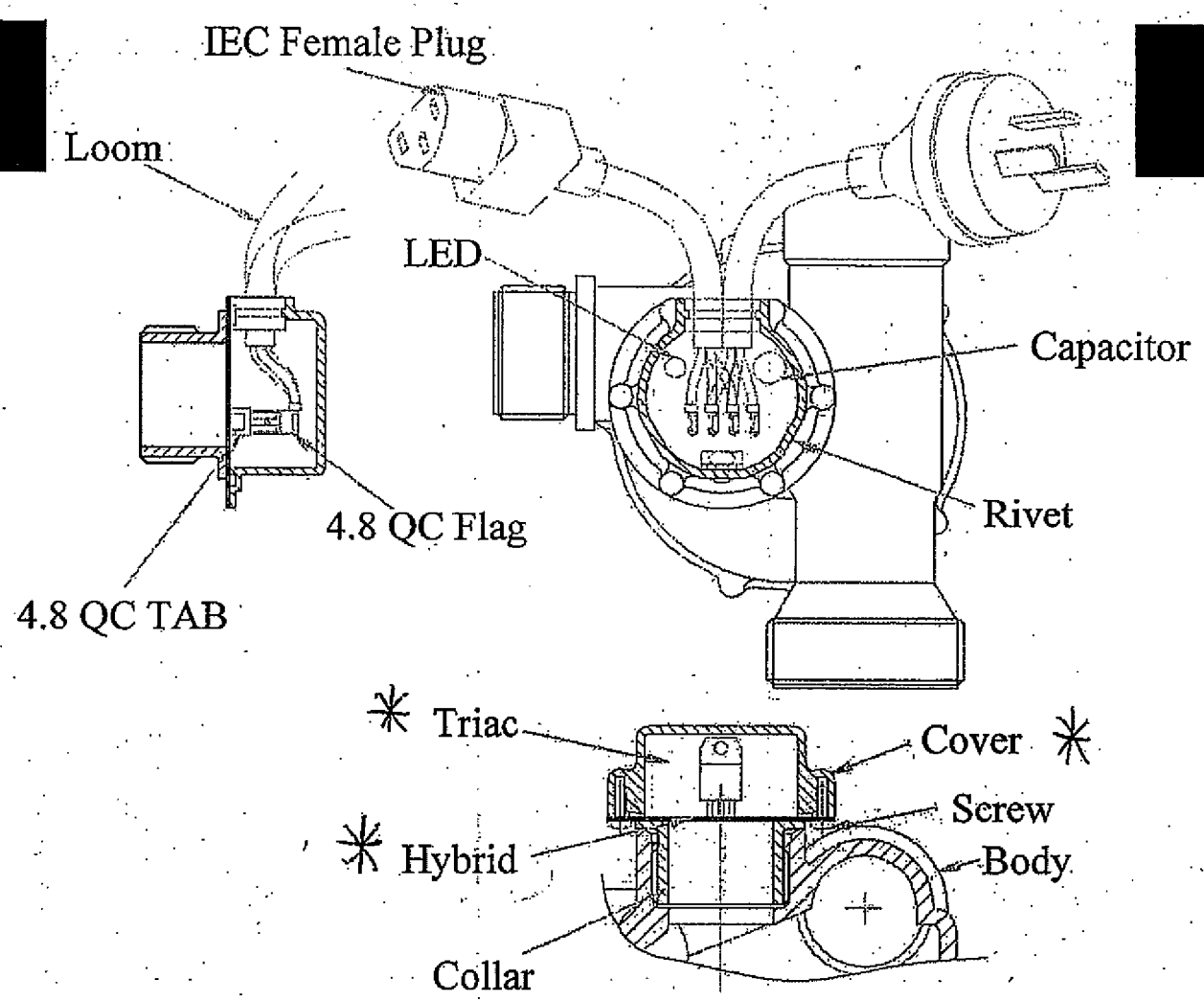
- a single housing, containing the sensors and electronics, an accumulator and a non-return valve;
- a screw-in sensor and electronics module.

Both options allow an external add on accumulator;

Both options meet the Davey requirement of isolation of the electronics from the high-pressure water.

[redacted]

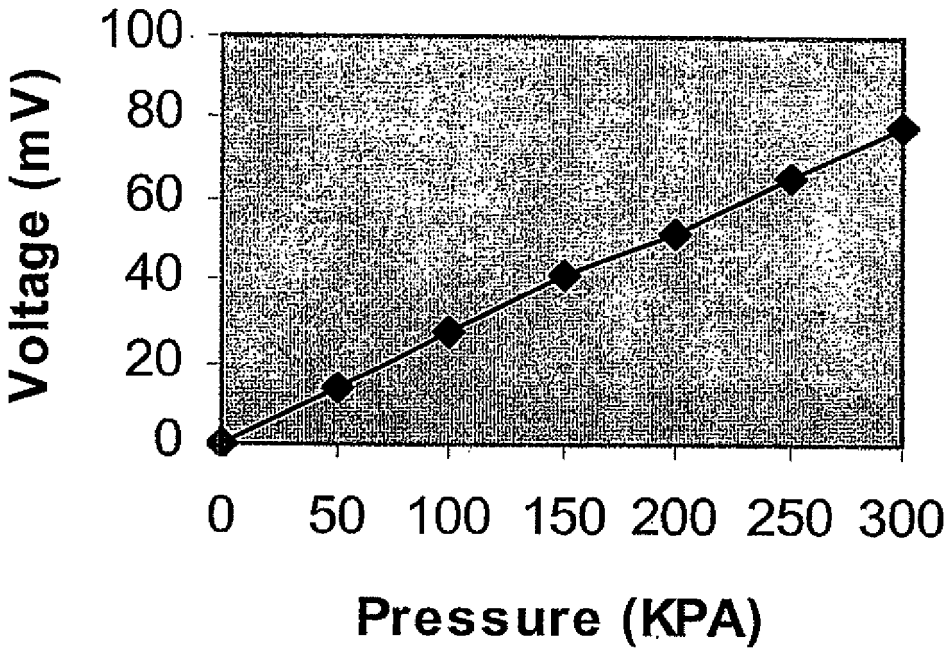
[redacted]



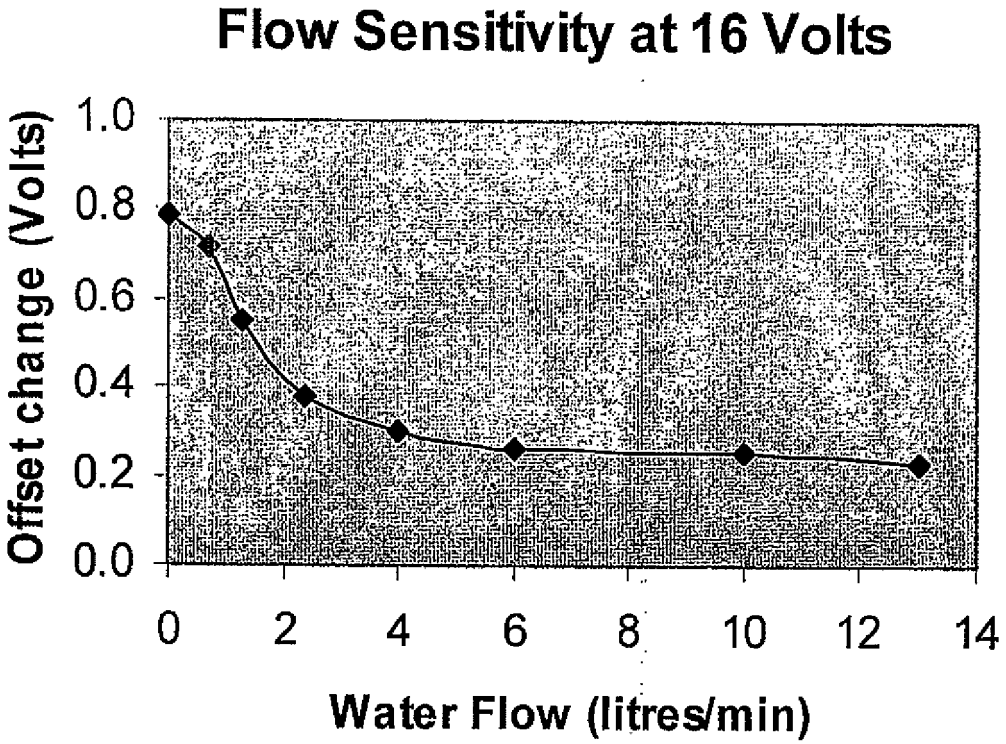
Screw-in Stainless Steel Design

[redacted]

Strain Gauge Sensitivity at 16 Volts



This graph shows the high sensitivity of the unique thick film on stainless steel technology for strain gauge pressure measurement.



This graph shows the high sensitivity of the unique Davey flow sensor.

Electronics

- We can measure the onset of losing prime by the simultaneous drop of pressure and flow. This can raise an alarm.
- We can provide for a variable flow cut-off as a separate part to Davey, as a variable adjustment on the unit or as an adapting learning sequence for the microprocessor.
- We can examine in detail the opportunity for flow on switching as well as flow off switching as it could have a major impact on the accumulator requirement.

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ATTACHMENT D

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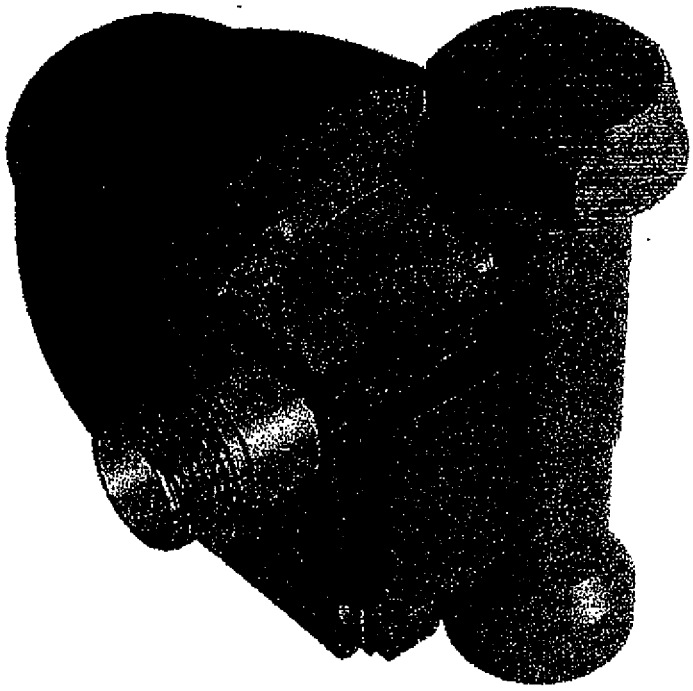
Dated: 14 - March 2008.

DESIGN REPORT

PHASE-I DEVELOPMENT

PUMP CONTROLLER – MONSOON (B1)

FOR DAVEY PRODUCTS PTY LTD



AUSTRALIAN ARROW PTY LTD

November 2000

1. DESIGN REPORT ON MECHANICAL DEVELOPMENT BY ARTIMECH

DESIGN REPORT ON ELECTRONICS DEVELOPMENT BY HYBRID ELECTRONICS

DESIGN REPORT ON MECHANICAL DEVELOPMENT BY ARTIMECH

1.1 Design details

The following 3D CAD models represent the latest stage of design of the mechanical components:

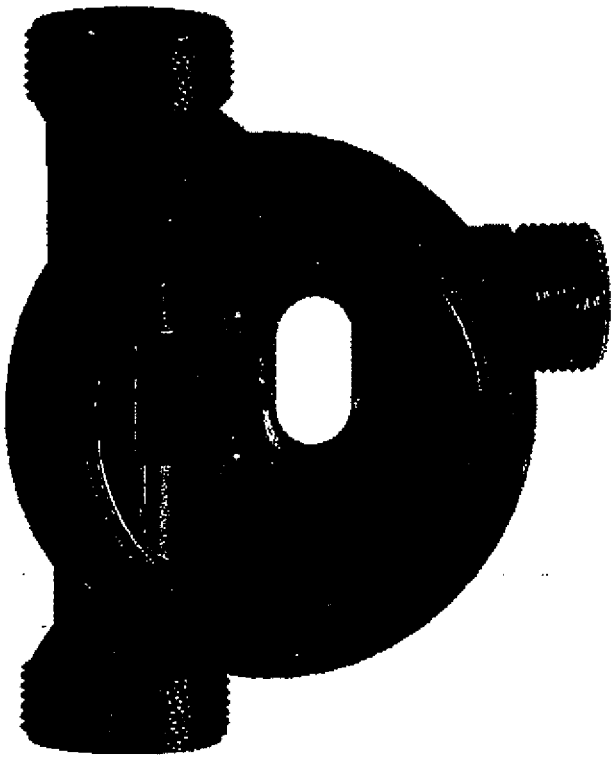
Part Number	*Rev*	*Part Name*	*Model Number*
N006D001	R01	Housing – Main	N006M001-R01 housing – main.par
N006D002	R01	Cover – Accumulator	N006M002-R01 cover – accumulator.par
N006D003	R01	Hybrid Substrate	N006M003-R01 hybrid substrate.par
N006D004	R01	Support – Water Side	N006M004-R01 support - water side.par
N006D005	R01	Spring – Accumulator	N006M005-R01 spring – accumulator.par
N006D006	R01	Support – Spring Side	N006M006-R01 support - spring side.par
N006D007	R01	Diaphragm	N006M007-R01 diaphragm.par
N006D008	R01	Piston – NRV	N006M008-R01 piston - NRV.par
N006D009	R01	Sleeve – NRV	N006M009-R01 sleeve - NRV.par
N006D010	R01	Spring – NRV	N006M010-R01 spring - NRV.par
N006D011	R01	Cover – Hybrid	N006M011-R01 cover - hybrid.par
N006D012	R01	Grommet – Harness	N006M012-R01 grommet - harness.par
N006D013	R01	Cap – NRV	N006M013-R01 cap – NRV option2.par
			N006M013-R01 cap – NRV option1.par *
N006D014	R01	Coupling – Accumulator	N006M014-R01 coupling accumulator option2.par
			N006M013-R01 coupling accumulator option1.par *
N006D015	R01	Deflector	N006M015-R01 deflector option2.par
			N006M015-R01 deflector option1.par

** note that if this option is used, the Davey barrel nut is also required (not drawn)*

Drawings have also been completed for each of the parts. These correspond to the part numbers listed above. Where 2 options exist for the same part the drawings are noted according to their option number.
Material specifications and in some cases, options, are listed on the appropriate drawings.

1.2 Specific comments on design features:

Body



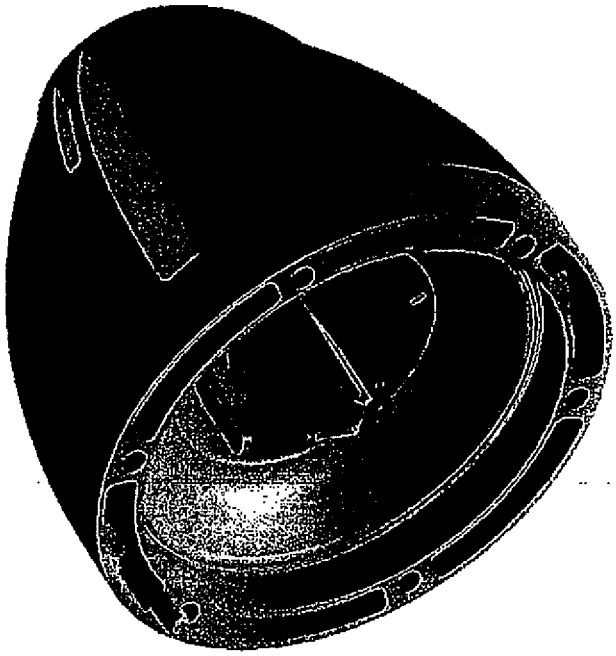
The body is designed incorporating form features requested by Davey for styling differentiation. Mounting and sealing surfaces for the other components are detailed and geometric tolerances specified.

The Hybrid O-Ring sealing face is designed in accordance with Dowty recommendations. The inlet and NRV connection points and sealing details are as per the current Davey Hydrascan design. Diaphragm sealing details are similar to the Press Control unit. The Cover-Hybrid sealing and NRV seating details are original.

Note that the form of the water path is important for correct sensor function, particularly with relation to the position of the outlet fitting relative to the hybrid.

The material specified is UV stabilised Noryl GFN2 or Nylon 6, 30% glass filled, which offers good strength and long-term creep resistance if working stresses are kept below the target of 20MPa.

Accumulator Cover



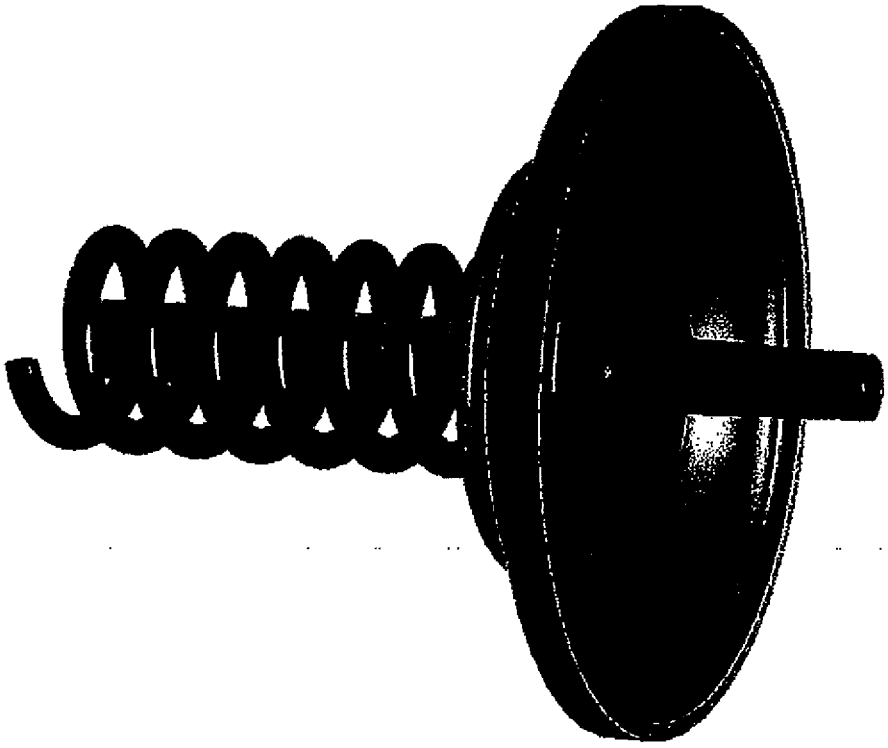
The accumulator cover incorporates significant external ribbing, again primarily for styling purposes. These ribs also improve the rigidity of the cover under extreme pressures.

The location of the accumulator spring and diaphragm is similar to the press control unit.

There are six screws holding the cover to the main body. This is less than the 8 retaining the same part in the Press Control assembly, however the screws specified are larger. The thickness of the mating flange to the body and the area in compression under the screw head are important factors for the long-term creep resistance of the part under pressure.

The material specified is Nylon 6, 30% glass filled.

Diaphragm Assembly



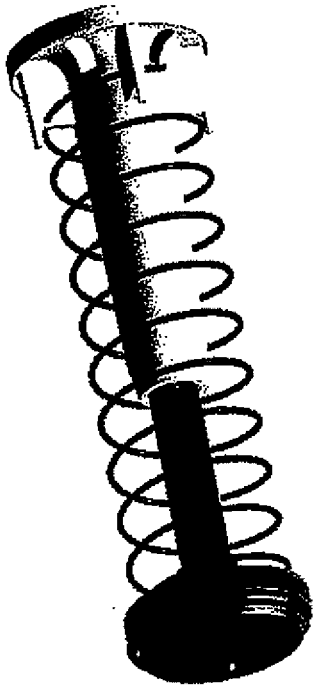
The diaphragm rubber is as per that in the Press Control unit.

The diaphragm supports are similar to those in the Press Control unit but use a screw to retain the diaphragm at its centre.

The support assembly also preloads the spring via the seat on the main body for the support post.

The material is Noryl GFN2 or Nylon 6, 30% glass filled (UV stabilisation not necessary).

Non-Return Valve



The non-return valve assembly has a number of important features.

The spring is designed to ensure reliable closure of the valve and to assist removal of the assembly for priming. The sleeve and piston have a sliding connection using a barb arrangement.

This barb needs to be optimised to avoid stiction yet maintain reliable attachment of the two parts on disassembly. The two iterations tried to date represent opposite extremes in this regard although both were close to acceptable.

The sliding arrangement also incorporates a slot in the piston to facilitate water escape from the sleeve as the piston retracts.

The sleeve has a number of slots on its seating face to enable water passage in the situation where an external accumulator is fitted.

The material specified for the piston and sleeve is chlorine stabilised Acetal, which offers excellent dimensional stability and minimum distortion at parting lines – important for O-Ring groove on the piston.

Flow Deflector

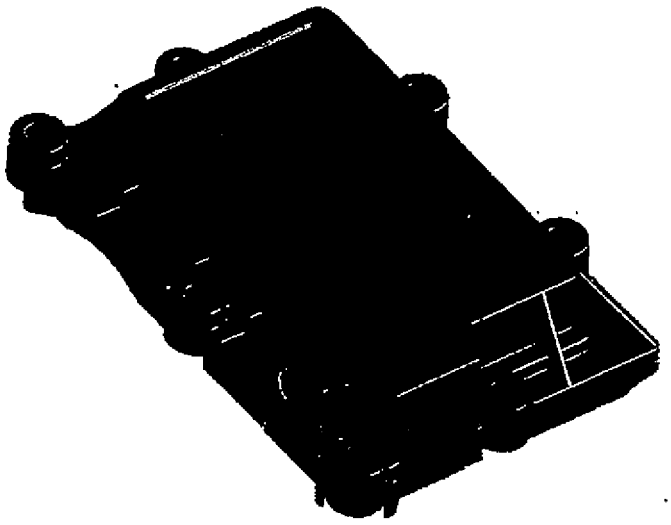
Out of many deflectors tested, there are currently two satisfactory designs available for the flow deflector. The form of this part could still be further improved.

The first option is a slightly modified flat plate to restrict flow exiting the chamber to pass consistently over the hybrid.

The second option, yet to be tested, should perform the same function but with less pressure drop, due to the "trumpet" feature.

The deflector is heat staked to the main body. The material specified is polypropylene as the part is not subject to high load and is not exposed to external environmental factors.

Cover – Hybrid



The cover for the hybrid is designed to meet a number of functional features.

The envelope completely encases the edge of the stainless steel hybrid substrate and clips secure the two parts for shipment between Hybrid manufacture and final assembly. The edge of the moulding also incorporates a groove to retain the environmental sealing O-Ring.

The cover is designed to incorporate a moulded grommet in the wiring harness, which performs the functions of sealing, locating the sealing O-Ring and, importantly, retaining the wiring firmly in case of "tugging" loads on the harness. This is achieved by locating the two branches of the wiring on either side of the corner locating and mounting lug. Cover in the grommet area may require strengthening.

There are two light columns incorporated into the moulding to serve the on-board diagnostic LED's. These holes are to be sealed by transparent windows in the adhesive label to be attached to the cover.

The cover has seven locating lugs that provide for screws to attach cover and hybrid to the main body. These lugs are designed to isolate the screws from the steel substrate (via pilot sleeves) and maintain an even load on the cover and the hybrid (for which the thickness of the part around its perimeter is important.

The material specified for the cover is UV stabilised Polypropylene, 30% glass filled. This is to achieve toughness (for impact protection) and to meet the external environmental conditions. Generally the part is not subject to any significant loading, so the glass filled nylons are not required.

Hybrid Substrate

The hybrid substrate is designed as a blanked and machined part to achieve the necessary dimensions for accurate function as a sensor within the minimum overall dimensions for packaging in the printing process and maximum utilisation of space for the electronics.

The mounting positions are designed as forks to minimise the packaging size and to facilitate forming in this material – stainless steel 316L . Fork design could be reviewed as concerns have been raised on variation of clamping force and of efficiency in assembly.

Fasteners

The fasteners specified for attachment of the Hybrid and Accumulator cover are either PT screws or Plastite. Both these proprietary designs offer superior load carrying capacity and better stress distribution in the plastic bosses when compared to conventional self-tapping screws. Therefore they should achieve better long-term creep and burst pressure performances. Shape of head of fastener could be reviewed for easy assembly.

1.3 Rapid prototype

Three iterations of SLS rapid prototypes have been produced by Concentric Asia Pacific. The latest parts provided are representative of the R01 design level CAD. The parts used for the majority of testing were to the previous R00 design level.

The parts are manufactured from a glass filled nylon 11 based material. Material properties are attached.

1.4 Performance to Specification

The following mechanical development tests have been completed and reported. Note that the tests are preliminary development tests designed to identify and estimate factors that govern flow and pressure measurements. Specifications that are to be met by properties of materials are not truly verified in these tests.

The summary reports describe individual tests carried, equipment used and observations made. Further information is available in the form of detailed test results and photographs/sketches of the set-up.

1. Head loss

- The specified pressure drop is easily achieved, even with significant flow deflecting devices

2. Accumulator capacity

- As the accumulator design was similar to an existing controller, intention was to duplicate performance of benchmark unit. Observations indicate varying behaviour under changing pressure conditions.
- Subsequent discussions with Davey indicate that accumulator design is not optimal and further development work will be required – refer to recommendations below
- It is anticipated that the requirements can be met with 2 spring calibrations for the ranges – 100-500 kPa, and 200-1000 kPa.

3. Back pressure

- This test was conducted to determine where the unit would fail, considering the material properties of the SLS prototype were approximately half those of the production material and the hybrid substrates were not to the correct design level – under-supported with 5 screws in lieu of the designed 7.
- The part blew hybrid seal at half the target pressure(~800kPa) indicating that the pressure is achievable with the production units made of correct materials.
- The test will need to be redone with more representative parts – see also the FEA report

4. Physical drop from 1m

- Only superficial scratches were observed and again, consider that the material properties of the production parts will be different and therefore to be repeated with correct material and weight of assembled unit.

5. Water flow characteristics

- Several trials were conducted with a combinations of flow control devices and designs to achieve acceptable flow over the hybrid to obtain desired sensitivity to variation of flow.
- While an acceptable solution has been identified (and released in above designs) further development could yield further enhanced performance – see recommendations below

6. 25kg load capacity

- The unit passes this test easily without cover-hybrid and is expected to pass with cover-hybrid too.

7. Water hammer

- There was no loss of function after 200 cycles

FEA analysis has been completed on the design for the following conditions:

1. Hybrid substrate deflection under pressure (2MPa)

- The deflections predicted are of the order of 0.007mm and is insignificant with regard to sealing integrity

2. NRV – valve induced stress levels under back pressure conditions (2MPa)

- The stress levels predicted are of the order of 20MPa and are acceptable

3. Induced stress levels in housing under back pressure conditions (2MPa) with tightening load of 1000N at each of six screws

- The stress levels predicted were acceptable, generally below the 20MPa target for long-term creep resistance with the material specified

4. Induced stress levels in accumulator cover under spring load and diaphragm pressure

- The stress levels predicted were acceptable, generally below the 20MPa target

1.5 Further Development

In our assessment the design as it currently stands demonstrates capability to perform the functions of the pump controller and is capable of meeting the design requirements with refinement of the design. This can be verified early in phase II of development using silicon-moulded parts or parts molded with correct materials using bridge tooling.

The following activities are viewed as valuable enhancements to an already satisfactory design.

Flow Deflector

Flow deflector could be enhanced with further combinations of deflector features and with more testing. It is recommended that several weeks be allocated to this task in the next phase of the program to improve sensitivity of flow sensor and minimise pressure drop at higher flow rates.

Accumulator Function

Accumulator is a bench marked design and it requires detail design change to develop parameters for critical components such as springs and diaphragm.

It is proposed that approximately 2-3 weeks would be required to determine the optimum spring specifications to achieve the 30ml requirement with minimum different spring sets.

Stainless Steel Accumulator (An alternative)

The concept for the stainless steel accumulator is yet to be developed and could be investigated concurrently with phase II of the program.

Retention of Hybrid Assembly

It has been discovered during the development that the retention of the hybrid substrate with the screws can induce variation into the sensor readings if the screws/cover is not located and fastened correctly. Semi circular holes at mounting positions may reduce assembly efficiency.

There is scope to further develop the mechanics of the attachment to reduce the sensitivity of the hybrid to the fastening pressure. Much of this could be undertaken using FEA tools and confirmatory tests.

DESIGN REPORT ON ELECTRONICS DEVELOPMENT BY HYBRID ELECTRONICS

2.1 Control Module Concept

The concept of the control module is a replaceable thick film hybrid module, on stainless steel, incorporating an integrated flow measurement and switch, an integrated pressure measurement with adaptive pump turn on switching and the power components to control the pump.

The unit presented is capable of meeting all of the required specifications but may not have complete software at this stage.

2.2 Mechanical Design

The initial concept was for a thin flat steel hybrid circuit that was to be subsequently brazed to a collar for screwing into the pump housing. This was replaced with a flat steel concept having a thin section for sensor elements surrounded by a thicker area for control circuitry and mounting capability.

The thin section could be a brazed sheet or the thin membrane could be machined from the thicker steel. The steel specification is 316L.

The mechanical design concept has many benefits for the adaptive pump control module and a few minor drawbacks.

2.3 Benefits

- The steel hybrid is close to the water flow for greater sensitivity
- Flat components are easier to use in manufacturing the module
- The strength of the module is assured by the thicker segment
- A brazed thinner section (provided this is not at too high a temperature) allows use of automatic printing and firing processes
- Shaping of the housing can result in a high flow signal level at a very low head loss

2.4 Drawbacks

- Water pressure transfer through the structure develops tension over all of the membrane and reduces the pressure sensitivity
- Attaching the module to the housing creates a variable pre-stress, although this is reduced in the latest design incorporating a cover
- Using a machined plate, costs are increased due to the need for slower manual printing processes and due to the high steel plate cost
- Difficulty has been experienced in obtaining a steady flow output signal and further housing shape adjustment is recommended

2.5 Software

Software presented provides basic adaptive pressure pump control as well as supply voltage measurement for flow signal compensation, water temperature measurement for pressure signal compensation, locked rotor protection, water over-temperature protection, many alarm codes and retry functions.

Some functions such as cistern filling, and locked rotor shake and retry, have not had their software de-bugged at the writing of this report.

2.6 Electronic Design

Electronic design has been based on the following objectives:

- A single module concept (this needs to be reconsidered if a machined plate is used)
- Triac cooling into the water
- A high reliability resistor generated power supply from mains voltage
- Dry sensor detection by low heater warming
- Maximum utilisation of the microprocessor for signal compensations
- Alarm signalling by flashing led
- Provision for a manual over-ride switch

All of the objectives have been met with the unit presented with the following exceptions

- Flow switch has a slight temperature compensation requirement for which the software has not yet been written. (this is probably due to resistor tcr's being ten times higher on steel than on ceramic. other materials will be used in production)

- Manual over-ride switch should also reset the microprocessor and clear alarm signals this will be done on the production version

2.7 Further Development Work

Further development work is required during next phase of the program in the following areas:

- 'Best solution' software assessment for alarms, stop and re-start pump situations and customer benefit software such as cistern filling, dripping tap solutions and external accumulator options

- Housing assessment for more stable flow measurement (stable flow measurement could be obtained by incorporating a wire grid over the sensor region but this is not recommended)

- Examinations of lower temperature brazing options to allow high speed automatic printing. (a high temperature pre printing brazing process was successfully completed and qualified)

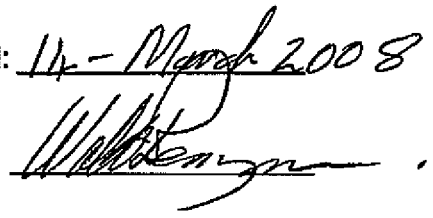
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	W. H. BERRYMAN, H. B. McDONALD	
Serial No.	:	10/814,178	
Filed	:	April 1, 2004	Group Art Unit 3746
Examiner	:	WEINSTEIN, LEONARD J	
Title	:	PUMP CONTROL SYSTEM	

ATTACHMENT E

to the Declaration of W. H. Berryman

Dated: 14 - March 2008



CLAIMS	REDUCTION TO PRACTICE SUPPORT
1. A pump controller for controlling a pump for a fluid medium such as water, said pump controller including:	Declaration, paragraphs 7 and 8 Attachment C – 1st slide Attachment D - Section 2.1
a metal substrate adapted to have a first side thereof exposed to said fluid medium;	- Attachment C – 3rd slide
an insulating medium applied to a second side of said substrate;	
pressure sensing means including at least one pressure responsive element implemented on said insulating medium closely adjacent said substrate such that said pressure element is responsive to pressure of said fluid medium when said first side is exposed to said fluid medium;	- Attachment C – 3rd and 7th slides
flow sensing means including at least one source of heat and at least one temperature responsive element implemented on said insulating medium closely adjacent said substrate, such that said temperature responsive element is responsive to flow of said fluid medium when said first side is exposed to said flow, said fluid medium providing a sink for said source of heat in a manner that is related to said flow;	- Attachment C – 3rd and 8th slides
switching means for switching said pump on or off; and	- Attachment C – 6th slide Attachment D – Section 2.6
processing means for receiving data from said pressure sensing means and said flow sensing means, said data being communicated via conductive tracks implemented on said insulating medium, said processing means being adapted for processing said data and for producing an output for driving said switching means.	- Attachment C – 9th slide, 2nd slide (the conductive tracks are visible in the left side photograph of the 4th slide)
2. A pump controller according to claim 1 wherein said metal substrate includes titanium.	
3. A pump controller according to claim 1 wherein said metal substrate includes low carbon stainless steel.	- Attachment C – 3rd, 4th, 6th and 7th slides Attachment D – Section 1.2 under heading "Hybrid Substrate"

4. A pump controller according to claim 1, wherein said insulating medium includes a ceramic.	- Attachment C – 3rd slide (reference to dielectric coating") Attachment D – Section 2.6 (2nd paragraph, 2nd dot point reference to "ceramic")
5. A pump controller according to claim 1 wherein said pressure responsive element includes a plurality of resistors formed by conductive tracks on said insulating medium, said resistors being arranged such that pressure on said substrate is measured by a change in value due to tension on said resistors.	- Attachment C – 3rd and 7th slides
6. A pump controller according to claim 1 wherein said temperature responsive element includes an operational amplifier and a bridge circuit containing a plurality of thermisters.	
7. A pump controller according to claim 1 wherein said switching means includes a triac.	- Attachment C – 6th slide Attachment D – Section 2.6 (2nd dot point)
8. A pump controller according to claim 7 wherein said triac is mounted on said substrate to provide said source of heat.	
9. A pump controller according to claim 1 wherein said at least one temperature responsive element includes a temperature sensor on each side of said metal substrate for detecting a temperature difference between said first and second sides.	
10. A pump controller according to claim 9 wherein said processing means is adapted to compensate for anomalies caused by said temperature difference.	- Attachment D – Section 2.5 (reference to "water temperature measurement for pressure signal compensation")
11. A pump controller according to claim 1 wherein said processing means includes a microprocessor or microcontroller.	- Attachment C – 9th slide (2nd dot print) Attachment D – Section 2.6 (5th dot point)

12. A housing for a sensor substrate having a wet side and a dry side and adapted to promote contact of said wet side with a fluid medium and to substantially prevent contact of said dry side with said fluid medium, said housing including: a main body having an opening for said fluid medium and for receiving said sensor substrate with its wet side exposed to said opening; a first chamber maintained substantially at atmospheric pressure; first sealing means arranged between said opening and said sensor substrate such that a leak path is provided to said first chamber; a closure for said housing including a second chamber exposed to said dry side of said sensor substrate; and second sealing means arranged between said closure and said first chamber to substantially prevent ingress of said fluid medium to said second chamber. 13. A housing according to claim 12 wherein said first sealing means includes a peripheral bead interposed between said wet side of said sensor substrate and an inner edge of said opening. 14. A housing according to claim 12 wherein said second sealing means includes a peripheral bead interposed between an edge associated with said first chamber and said closure. 15. A housing according to claim 12 wherein said first and second sealing means are connected by a membrane, said membrane providing an additional barrier to moisture reaching said dry side of said sensor substrate. 16. A housing according to claim 15 wherein said membrane includes a recess for receiving a peripheral edge of said sensor substrate.	- Attachment C – 6th slide, element labelled "cover" Attachment D – Section 1.2 under the heading "Cover-Hybrid") Declaration, paragraph 10

17. A housing according to claim 12 wherein said first and second sealing means are formed from an elastomeric material. 18. A housing according to claim 12 wherein said membrane is formed from an elastomeric material. 19. A housing according to claim 12 including a venturi device adapted to accelerate flow of pumped fluid in the vicinity of said opening.	